C L A I M S

1. An optical element having a variable optical characteristic comprising: an optical element using a substance which has a variable refractive index and is dispersed in polymers; and a driving device which varies the refractive index of said substance.

2. An optical element having a variable optical characteristic which uses a polymer dispersive liquid crystal.

3. A vari-focal diffractive optical element which uses a combination of a polymer dispersive liquid crystal and a diffractive optical element.

4. An optical element capable of varying a declination angle which uses a polymer dispersive liquid crystal.

5. A vari-focal mirror which uses a polymer dispersive liquid crystal.

6. A vari-focal lens element which uses a polymer dispersive liquid crystal.

7. An optical element having a variable optical characteristic according to Claim 1 comprising in order from a side of light incidence: a first optical member which has a first surfaces and a second surface; a second optical member which has a third surface and a fourth surface; a pair of transparent electrodes; a polymer dispersive liquid crystal layer interposed between said transparent electrodes; and means for applying an electric field to said polymer dispersive liquid crystal layer by way of said transparent electrodes, wherein an optical characteristic is varied by changing a refractive index of said liquid crystal layer by applying an electric field to said polymer dispersive liquid crystal layer by said means.

8. A diffractive optical element having a variable optical characteristic according to Claim 3 comprising in order from a side of light incidence: a first optical member which has a first surface and a second surface; a second optical member which has a third surface and a fourth surface; a diffractive surface which is formed on at least one of said first surface, said second surface and said third surface; a pair of transparent electrodes; a polymer dispersive liquid crystal layer interposed between said transparent electrodes; and means which for

applying an electric field to said polymer dispersive liquid crystal layer by way of said pair of transparent electrodes, wherein an optical characteristic is varied by changing a refractive index of said polymer dispersive liquid crystal layer by applying an electric field to said liquid crystal layer by said means.

9. A variable declination prism according to Claim 4 comprising in order from a side of light incidence: a first optical member which has a first surface and a second surface; a second optical member which has a third surface and a fourth surface; a polymer dispersive liquid crystal layer which is interposed between a pair of transparent electrodes; and means for applying an electric field to said polymer dispersive liquid crystal layer by way of said transparent electrodes, wherein at least one of said first surface, second surface and third surface is inclined relative to an optical axis of an incident light bundle and wherein a declination is varied by changing a refractive index of said polymer dispersive liquid crystal layer by applying an electric field to said liquid crystal layer by said means.

10. Vari-focal spectacles which use a vari-focal optical element as claimed in Claim 2, 3, 6, 7 or 8.

11. A light deflector equipped with at least one prism having variable declination angle as claimed in Claim 4 or 9.

12. An image pickup apparatus equipped with an optical element having a variable optical characteristic as claimed in Claim 2, 3, 4, 5, 6, 7 or 8.

13. An optical element having a variable optical characteristic according to Claim 2, 3, 4, 5, 6, 7, 8 or 9, wherein said polymer dispersive liquid crystal layer satisfies the following condition (18):

$$0.1 \leqq ff \leqq 0.999 \qquad (18)$$

wherein the reference symbol ff represents a ratio of a volume occupied by liquid crystal molecules relative to a volume of the polymer dispersive liquid crystal layer.

14. An optical element having a variable optical characteristic according to Claim 2, 3, 5, 6, 7, 8 or 9, wherein said polymer dispersive liquid crystal layer satisfies the following condition (19):

$$4 \times 10^{-6}\ [\mu m]^2 \leqq D \cdot t \leqq \lambda \cdot 45\ [\mu m] \cdot (1.585-1.45)^2/(n_U - n_E)^2 \qquad (19)$$

wherein the reference symbol D represents a mean diameter of polymer cells containing liquid crystal

molecules which compose the polymer dispersive liquid crystal layer, the reference symbol t designates a thickness of the polymer dispersive liquid crystal layer as measured in a direction along an optical axis, the reference symbol λ denotes a wavelength of a ray to be used, the reference symbol n_P represents a refractive index of polymers composing the polymer cells and the reference symbol $(n_u - n_P)^2$ designates a value of $(n_{LC}' - n_P)^2$ or a value of $(n_0' - n_P)^2$ whichever is larger. The reference symbols n_{LC}', n_0' and n_P represent a mean refractive index of the liquid crystal molecules, a refractive index of the liquid crystal molecules for the ordinary ray and a refractive index of the polymers composing the polymer cells respectively.

15. An optical element according to Claim 14 satisfying, in place of the condition (19), the following condition (19-5).

$$4 \times 10^{-6}\ [\mu m]^2 \leqq D \cdot t \leqq \lambda \cdot 450\ \mu m \cdot (1.585-1.45)^2/(n_u - n_P)^2 \quad (19\text{-}5)$$

16. An optical element having a variable optical characteristic according to Claim 13, wherein said polymer dispersive liquid crystal layer satisfies the following

condition (19):

$$4 \times 10^{-5}\ [\mu m]^2 \leqq D \cdot t \leqq \lambda \cdot 45\ \mu m \cdot (1.585-1.45)^2/(n_u - n_p)^2 \quad (19)$$

wherein the reference symbol D represents a mean diameter of polymer cells containing liquid crystal molecules which compose the polymer dispersive liquid crystal layer, the reference symbol t designates a thickness of the polymer dispersive liquid crystal layer as measured in a direction along an optical axis, the reference symbol λ denotes a wavelength of a ray to be used, the reference symbol n_p represents a refractive index of polymers composing the polymer cells and the reference symbol $(n_u - n_p)^2$ designates a value of $(n_{LC}' - n_p)^2$ or a value of $(n_o' - n_p)^2$ whichever is larger. The reference symbols n_{LC}', n_o' and n_p represent a mean refractive index of the liquid crystal molecules, a refractive index of the liquid crystal molecules for the ordinary ray and a refractive index of the polymers composing the polymer cells respectively.

17. An optical element having a variable optical characteristic according to Claim 2, 3, 4, 5, 6, 7 or 8, wherein said polymer dispersive liquid crystal layer satisfies the following condition (1):

$$2\ nm \leqq D \leqq \lambda/5 \qquad (1)$$

wherein the reference symbol D represents a mean diameter of polymers containing liquid crystal molecules composing said polymer dispersive liquid crystal layer and the reference symbol λ designates a wavelength of a ray to be used.

18. An optical element having a variable optical characteristic according to Claim 2 satisfying the following condition (1-1):

$$2\ nm \leqq D \leqq \lambda \qquad (1\text{-}1)$$

wherein the reference symbol D represents a mean diameter of liquid crystal molecule cells and the reference symbol λ designates a wavelength of a ray to be used.

19. An optical element having a variable optical characteristic according to Claim 2, wherein said polymer dispersive liquid crystal layer satisfies the following condition (1):

$$2\ nm \leqq D \leqq \lambda/5 \qquad (1)$$

wherein the reference symbol D represents a mean diameter of liquid crystal molecule cells and the reference symbol λ designates a wavelength of a ray to be used.

20. An optical element having a variable optical characteristic according to Claim 13, wherein said polymer dispersive liquid crystal layer satisfies the following condition (20):

$$7\ \text{nm} \leqq D \leqq 500\lambda \qquad (20)$$

wherein the reference symbol D represents a mean diameter of liquid crystal molecule cells and the reference symbol λ designates a wavelength of a ray to be used.

21. An optical element having a variable optical characteristic according to Claim 2, 3, 4, 5, 6, 7 or 8, wherein said polymer dispersive liquid crystal layer satisfies the following condition (12):

$$0.01 \leqq |n_0' - n_{LC}'| \leqq 10 \qquad (12)$$

wherein the reference symbol n_0' represents a mean refractive index of the liquid crystal layer for the ordinary ray and the reference symbol n_{LC}' designates a mean refractive index of the liquid crystal layer.

22. Vari-focal spectacles which use an optical element having a variable optical characteristic as claimed in Claim 13 or 15.

23. An image pickup apparatus which uses an optical

element having a variable optical characteristic as claimed in Claim 13 or 15.

24. An optical instrument which uses an optical element having a variable optical characteristic as claimed in Claim 1 or 2.

25. A vari-focal mirror comprising in order from a side of light incidence: a first optical member which has a first surface and a second surface; a second optical member which has a third surface and a fourth surface; a pair of electrodes disposed on said two of the surfaces; a polymer dispersive liquid crystal layer interposed between said electrodes; and means for applying an electric field to said polymer dispersive liquid crystal layer by way of said electrodes, wherein a reflective surface is disposed on said third or fourth surface so that an incident ray transmits repeatedly through said polymer dispersive liquid crystal layer a plurality of times.

26. A vari-focal mirror comprising in order from a side of light incidence: a transparent electrode; a polymer dispersive liquid crystal layer; an electrode; and a reflective surface, wherein said vari-focal mirror comprises means for applying an electric field to said

polymer dispersive liquid crystal layer and wherein said vari-focal mirror is configured to allow an incident ray to transmit repeatedly through said polymer dispersive liquid crystal layer a plurality of times.

27. A manufacturing method of a lens element of a heterogeneous medium comprising: a step to grind an outside diameter of material of a heterogeneous medium to an outside diameter of a finished lens element using a centerless grinder.

28. A manufacturing method of a lens element of a heterogeneous medium comprising: a step to adjust deflection of an outer circumference of a material of a heterogeneous medium with a pick-tester or a microscope; and a step to grind an outside diameter of said material of the heterogeneous medium to an outside diameter of a finished lens element with said material kept fixed to a rotating shaft of a centering machine.

29. A manufacturing method of a lens element of a heterogeneous medium comprising: a step to form a curved surface having a desired shape on a material of a heterogeneous medium so that its center is nearly coincident with a center axis of a refractive index

distribution; and a step to grind an outer circumference of the material of the heterogeneous medium on which the curved surface has been formed using a bell clamp or a sider type centering machine until the outer circumference has an outside diameter of a finished lens element.

30. A manufacturing method of a lens element of a heterogeneous medium comprising: a step to grind and polish a material of a heterogeneous medium so as to have a planar surface while keeping it in a condition where it is fixed to a jig in a direction perpendicular to a grinding direction.

31. A manufacturing method of a lens element of a heterogeneous medium according to claim 30, wherein said jig to which the material of a heterogeneous medium is to be fixed is a V block or a gear.

32. A manufacturing method of a lens element of a heterogeneous medium comprising: a step to fix a material of a heterogeneous medium which has an outside diameter larger than that of a lens element of a heterogeneous medium and a curved surface of a desired shape into a hole which has a diameter nearly equal to that of said material of the heterogeneous medium and is formed at a center of a

fixture made of a glass, metal, resin or the like material, and grind and polish said material of the heterogeneous medium together with said fixture so as to form a curved surface of a desired shape.

33. A manufacturing method of a lens element of a heterogeneous medium comprising: a step to fix a material of a heterogeneous medium having a surface which has been ground into a first curved surface of a desired shape to a rotating shaft of a fixture having a curved surface of a shape which is the same as that of a second curved surface reverse to said first curved surface while adjusting deflection of an outer circumference with a pick tester or a microscope; and a step to grind the second curved surface of said material of the heterogeneous medium into a curved surface of a desired shape with a curve generator.

34. A manufacturing method of a lens element of a heterogeneous medium comprising: a step to form both ends of a material of a heterogeneous medium into curved surfaces of desired shapes respectively which have centers nearly coincident with a center axis of a refractive index distribution; and a step to center the material of the heterogeneous medium on which said curved surfaces are formed by the bell clamp method.

35. A manufacturing method of a lens element of a heterogeneous medium comprising: a step to form both ends of a material of a heterogeneous medium into curved surfaces of desired shapes each of which has a center nearly coincident with a center axis of a refractive index distribution; and a step to fix one of the curved surfaces of the material of the heterogeneous medium on which said curved surfaces are formed to a fixture having a curved surface of a shape which is the same as that of the other curved surface and center the material of the heterogeneous medium with a sider type centering machine while observing an image reflected by the other curved surface.

36. A manufacturing method of a lens element of a heterogeneous medium comprising: a step to form, at both ends of a material of a heterogeneous medium, curved surfaces of desired shapes each of which has a center nearly coincident with a center axis of a refractive index distribution; and a step to center the material of the heterogeneous medium on which said curved surfaces are formed with a sider type centering machine.

37. A manufacturing method of a lens element of a heterogeneous medium comprising: a step to grind one surface of a material of a heterogeneous medium into a

curved surface of a desired shape using a curve generator while keeping said material in a condition where it is fixed with a collet chuck.

38. A manufacturing method of a lens element of a heterogeneous medium comprising: a step to form a surface of a material of a heterogeneous medium into a curved surface of a desired shape which has a center nearly coincident with a center axis of a refractive index distribution; and a step to form the other surface into a curved surface of a desired shape using a curve generator while fixing the material of the heterogeneous medium with a collet chuck and supporting said curved surface with a pipe.

39. A manufacturing method of a lens element of a heterogeneous medium according to Claim 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37 or 38 wherein a center axis of said material of the heterogeneous medium is coincident with a center axis of its refractive index distribution.

40. A plate-like image pickup comprising: a transparent substrate; and at least an image pickup device and an optical element which are disposed on surfaces of said transparent substrate, wherein said plate like image

pickup unit has a function to pickup an image.

41. A plate-like image pickup unit which has a function to pickup an image comprising: a transparent substrate; an image pickup device, and at least one of a diffractive optical element, a lens element having curved surfaces, a mirror and a free curved surface which are disposed on surfaces respectively of said transparent substrate.

42. A plate-like image pickup unit having a function to pickup an image comprising: a transparent substrate; a view finder using said transparent substrate; an image pickup device; and at least one of a diffractive optical element, a lens element having curved surfaces, a mirror and a free curved surface.

43. A plate-like image pickup unit according to claim 41 further comprising a display unit which is disposed on a surface of said transparent substrate.

44. A plate-like image pickup unit according to Claim 40, 41, 42 or 43 manufactured by lithography.

45. A plate-like image pickup unit according to Claim 40, 41, 42, 43 or 44 comprising an optical element having a

variable optical characteristic.

46. A plate-like image pickup unit according to Claim 40, 41, 42, 43, 44 or 45, wherein said transparent substrate has a function of an infrared cut filter.

47. An image pickup apparatus comprising a plate-like image pickup unit as claimed in Claim 40, 41, 42, 43, 44 or 45.

48. A portable information terminal unit comprising a plate-like image pickup unit as claimed in Claim 40, 41, 42, 43, 44 or 45.